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ARM Facilities Newsletter

Lightning Safety and ARM Instrumentation

Last month we discussed the way lightning forms and then strikes. This month we will look at ways to protect ourselves and our property from the damaging threat of a lightning strike, as well as what ARM does to protect its array of scientific instrumentation and buildings.

About Lightning

Lightning packs a punch equal to 100 million volts of electricity, a force powerful enough to tear through roofs and explode walls and chimneys. A lightning strike can generate temperatures as high as 90,000 degrees Fahrenheit (three times hotter than the surface of the sun) and can easily ignite fires. In addition to causing property destruction, direct lightning strikes kill nearly 100 people each year, according to the National Lightning Safety Institute. Although the odds of being killed are low (1 in 28,500 per exposed individual), complete protection from a direct hit (to you or your house) is impossible. Nevertheless, some precautions will help you avoid injury or damage.

Protecting Buildings and Equipment

Lightning protection systems are the most useful method for safeguarding buildings and equipment against lightning damage. The systems are designed to collect electrostatic charge and provide a preferred path for the lightning energy traveling to the ground, then allow the charge to dissipate harmlessly. Most systems have three main components: air terminals (lightning rods), conductors, and grounding rods or plates. The initial buildup of electrical charge in the atmosphere due to a thunderstorm is picked up by the air terminal, transferred through the conductors, and dissipated deep underground through the grounding rod or plate. Because the charge is dissipated, no lightning flash takes place, keeping a building safe from damage. All lightning protection equipment must be designed to standards of the Lightning

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Technical Contact: Douglas L. Sisterson *Editor*: Donna J. Holdridge

Protection Institute, Underwriters Laboratories, the National Fire Protection Association, or the National Electrical Code.

Air terminals are constructed of solid or hollow copper or aluminum and are shaped into pointed rods that are mounted at the highest points on buildings, chimneys, and scientific installations. A pointed object is a good collector of electrostatic charge, and a tall

Figure 1. An air terminal and conductor mounted atop the Okmulgee, Oklahoma SMOS platform.

air terminal provides protection over a fairly large horizontal area. The goal is to make the air terminal the most efficient collector of atmospheric charge in the area. Heavy-gauge stranded copper or aluminum wire is used as the conducting cable, connecting the air terminals with grounding rods or plates buried in the ground.

Copper-clad ground rods driven into conductive soils are sufficient to provide good electrical contact with the ground for charge dissipation. Where bedrock is shallow and the ground is a poor conductor, copper plates are buried midway between the soil surface and the bedrock to increase contact with the soil and dissipate the charge.

Even when no lightning flash results, sudden electrical charges can cause electrical surges, spikes, sags, and blackouts that can seriously damage electronic equipment. Furthermore, electrical charge surges and spikes can follow power or telephone lines after a lightning strike has occurred nearby. The energy from a distant lightning strike can spread throughout a local electrical grid, causing damage along the entire route.

Surge protection devices in utility lines can provide some protection from electrical charges even before a lightning flash takes place. A surge protection device is connected between the power source and the appliance or component being protected. The surge device contains capacitors and resistors large enough to intercept and divert (to ground) the unusually large electrical pulses that would otherwise damage electronic equipment such as televisions, computers, and telephones.

Personal Protection

The National Lightning Safety Institute suggests several ways to protect yourself when a lightning storm approaches. First and foremost, seek shelter immediately. You put yourself at great risk by staying outdoors where you are unprotected. Indoors, stay away from doors, windows, electrical appliances, and electric outlets. Unplug appliances well before the approach of the storm, because small electrical surges due to nearby lightning

strikes can seriously damage appliances that are sensitive to power fluctuations. Stay away from plumbing, including sinks, bathtubs, and faucets. Lightning can enter your home through buried water supply lines, then travel through your metal piping and cause electrocution if you are in contact with the pipes (for example, while taking a shower). Do not use your telephone during a storm, because a lightning strike can travel through telephone wires and cause serious injuries. Also avoid natural gas pipes, which, like water supply lines, can transport lightning energy.

If you are outside when a lightning storm approaches, your first priority is to seek proper shelter, preferably inside a safe building or a metal vehicle with the windows fully closed. If this is not possible, seek shelter away from isolated trees, and avoid contact with electric wires, fences, clotheslines, metal pipes, motors, power tools, telephone poles, and other conductors. Also avoid bodies of water like lakes, ponds, and swimming pools. Stay away from isolated objects like single trees, canopies, or small picnic shelters. If no man-made shelter is available but a large grove of trees is nearby, position yourself in the middle of the grove, midway between trees. Put down objects that might conduct electricity, such as a rake, hoe, shovel, or golf club. Seek a position in a low spot, and minimize your contact with the ground by crouching down with only your knees and toes touching the ground. Cover your ears to protect your hearing from thunder. Don't lie flat on the ground, and stay at least 15 feet away from other people. If your hair stands on end, lightning might be about to strike nearby. Fifty-two percent of lightning deaths occur in open areas on water, fields, and golf courses, while 38% occur indoors and result from contact with telephones, water faucets, bathtubs, and appliances during an lightning storm.

Protecting ARM Structures

Many of the instruments and buildings at the ARM SGP facilities are isolated, individual structures or towers located in open fields or projecting from a forest. These structures are prime targets for lightning strikes. David Cook, a scientist and ARM instrument mentor at Argonne National Laboratory and the designated lightning protection consultant for the ARM Program, designed and directed the

Figure 2. A meteorological instrument tower with an installed lightning protection system. The air terminal is visible at the very top of the tower.

installation of lightning protection systems for most of ARM's buildings, instrument platforms, and towers. The instruments are protected by lightning protection systems using air terminals, conductors, and ground rods or plates. Each system was designed specifically for the individual instrument by taking into account the shape and size of the instrument and its mounting platform. The building lightning protection systems employ military-specification grounding grids for further protection from large inputs of lightning energy and radio frequency energy. Many of the ARM lightning protection designs exceed the established standards to ensure that personnel and ARM's investment in scientific instrumentation are protected from lightning. Injury or death due to a lightning strike is a tragedy, and damage to equipment would add cost to the program and create gaps in the ARM data collection.

More Information

Lightning and lightning protection are very complicated matters. We have touched only briefly on the subject in the last two issues of this newsletter. To learn more about this topic, consult the following printed and Web-based resources:

- NASA Web Page: Lightning Primer, http://thunder.msfc.nasa.gov/primer/primer2.html
- The National Lightning Safety Institute Web Page, http://www.lightningsafety.com
- Lightning Protection Institute Web Page, http://www.lightning.org
- *All About Lightning*, M.A. Uman, Dover Publication, New York, NY, 1986
- *The Lightning Discharge*, M.A. Uman, Academic Press, San Diego, CA, 1987
- *The Earth's Electrical Environment*, National Academy Press, Washington, DC, 1986